Lab – 1

Impact test to measure fracture energy of materials

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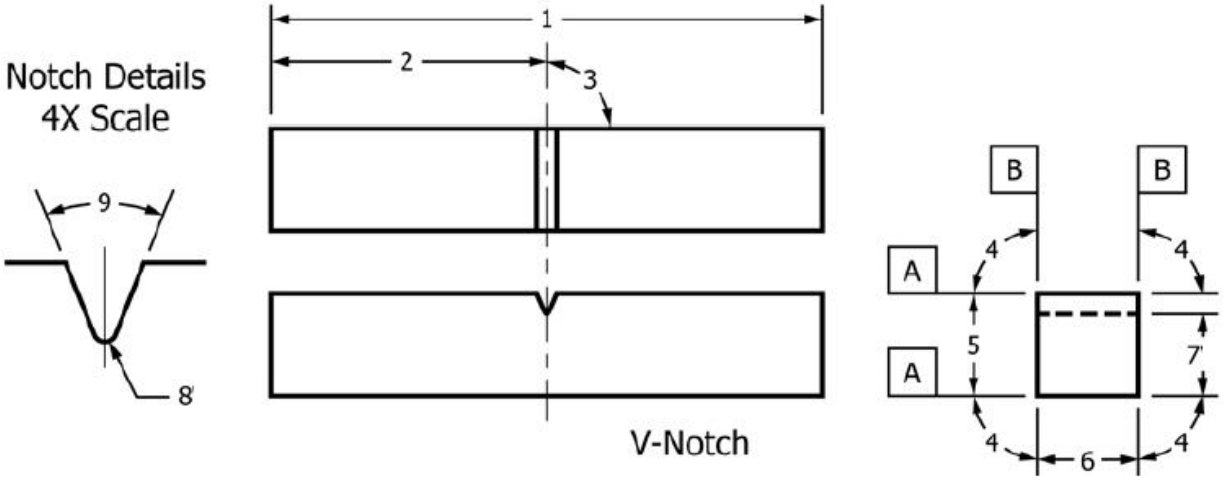
Objective

To determines the amount of energy absorbed by a material during fracture by evaluating its notch toughness.

Introduction

The Charpy impact test, also known as the Charpy V-notch test, is a standardized high strain-rate test which determines the amount of energy absorbed by a material during fracture. The absorbed energy is a measure of the material's notch toughness. The impact test method is widely used in industry because of a simple specimen preparation process, experimental procedure and data analysis.

Specimen Dimension



The test specimen shall conform to the dimensions and geometry as specified in table 1[1].

Figure 1.1. Charpy (Simple Beam) Impact test Specimen, V-notch

Each specimen shall be free of twist and shall be bounded by mutually perpendicular pairs of plane, paralleled surfaces and free from scratches, pits, and sink marks. The specimens shall be checked for conformity with these requirements by visual observation against straight edges, squares or at plates, and by measuring with micrometer calipers.

Table 1. Charpy V-notch specimen dimensions

S.N.	Description	Dimension	Tolerance
1	Length of specimen	55 mm	+0/-2.5mm
2	Centering of notch	-	±1mm
3	Notch length to edge	90^0	$\pm 2^0$

4	Adjacent side angle	90^0	$\pm 0.17^0$
5	Width	10mm	±0.075mm
6	Thickness	10mm	±0.075mm
7	Ligament length	8mm	±0.25mm
8	Radius of notch	0.25mm	±0.25mm
9	Angle of notch	45^0	$\pm 1^0$

Test Procedure

Impact test will be performed on INSTRON CEAST 9340 drop weight impactor (See, Fig. 1.2). The procedure to run the equipment and performing experiment is given in the following.

1. Switch on the compressor and set the pressure to 6 bar.
2. Power ON the Impactor equipment and press START at the control panel.
3. Place the pre-cracked specimen and align it with the loading tup.
4. At the control panel, go to Service option -> move to height -> change to H from Z.
5. Slowly move the tup downwards by using control panel, until it just touches the specimen. Now set H = 0 on the control panel.
6. Adjust the photo-sensor's location such that it gets activated before the impactor hits the specimen.
7. Open the CEAST software program on the computer and go to Process -> Parameters -> select appropriate ASTM standards.
8. Edit the test parameters in Process -> Parameters by providing appropriate values of the impactor mass, height / initial velocity / impact energy.
9. Go to Process -> Test execution -> Type in the operator name, test name etc.
10. In Process -> Parameters, choose ASTM E23 (for Charpy test)
11. Now press START on the computer. This moves the tup to its set height/position.
12. Press Continue to open the dialogue box. Click OK to begin the test.
13. Once the test is executed press END on the computer.
14. Go to Files on the computer interface, select the entered test name and extract the data. Save the raw data into an Excel sheet.

Figure 1.2. INSTRON CEAST 9340 drop weight impactor

Data analysis

Representative force vs. time data, obtained from the test is plotted in fig. 1.3. Calculate velocity and displacement histories from the force-time data by employing Eqs. (1) and (2) [2]. Plot force vs. displacement graph and calculate the energy absorbed by the material during fracture, by evaluating the area under the curve. Use appropriate numerical integration scheme to calculate the integrals in the equations. Also, plot force vs. time,

velocity vs. time and displacement vs. time data and analyze them. It is important to know that only force data is measured by the strain sensor, equipped with the impactor (loading tup). The velocity, displacement and energy data, tabulated in the machine generated excel file is based on analytical calculations for the given height and the mass of the impactor. Therefore, only force data from the excel file should be considered, while performing calculations. Report should also include the difference between the machine generated data and the data processed by using the force history.

$$v(t) = v_i + gt - \int_0^t \frac{F(t)}{m} dt \tag{1}$$

$$\delta(t) = \delta_i + v_i t + \frac{gt^2}{2} - \int_0^t \left(\int_0^t \frac{F(t)}{m} dt \right) dt \tag{2}$$

In the above equations v and δ represents the loading tup velocity and the displacement, respectively. The subscript i is used to denote the initial value of the parameter (at reference time t = 0). The g is gravitation acceleration (m/s^2), and m is the impactor mass. For more details, see the references.

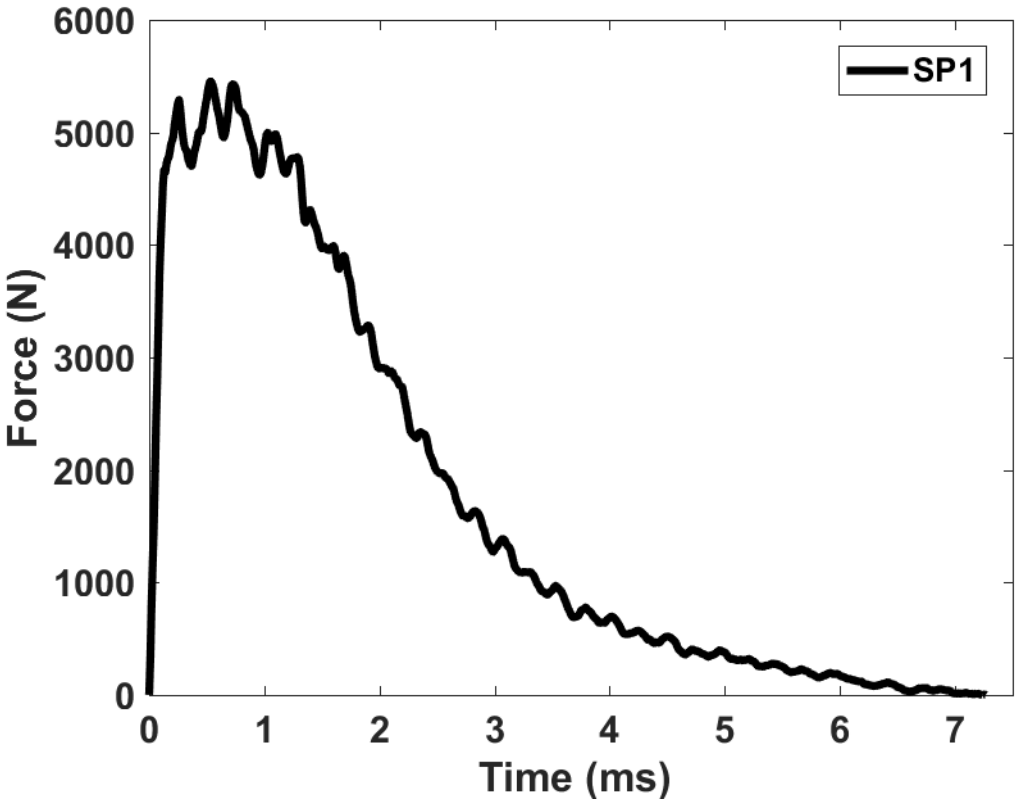


Figure 1.3. Force vs. time data obtained by performing Charpy impact test on aluminum specimen.

References

[1] ASTM E. "23. Standard Test Methods for Notched Bar Impact Testing of Metallic Materials" ASTM International (2007).

[2] ASTM, D. "7136. Standard test method for measuring the damage resistance of a fiber-reinforced polymer matrix composite to a drop-weight impact event." ASTM International (2001).